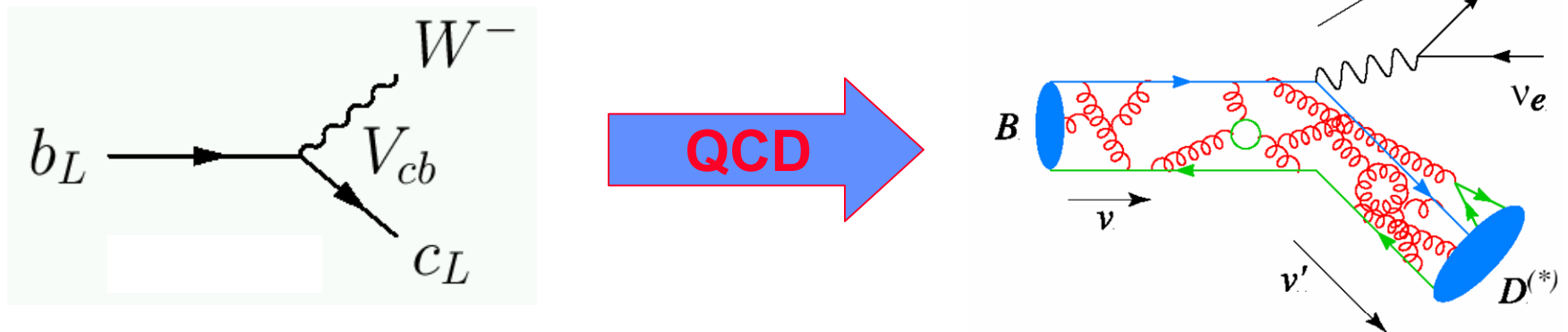


BaBar

David Brown
November 8, 2005

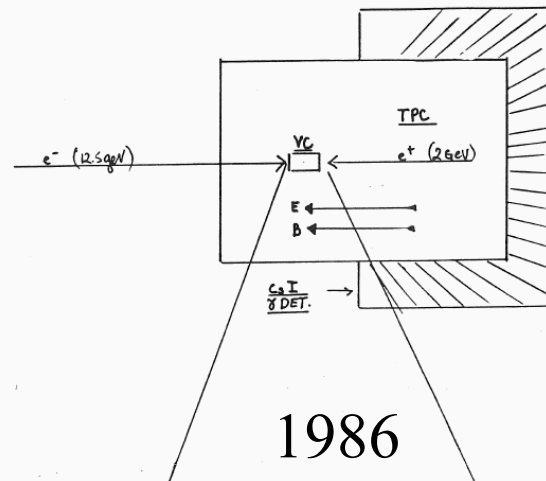
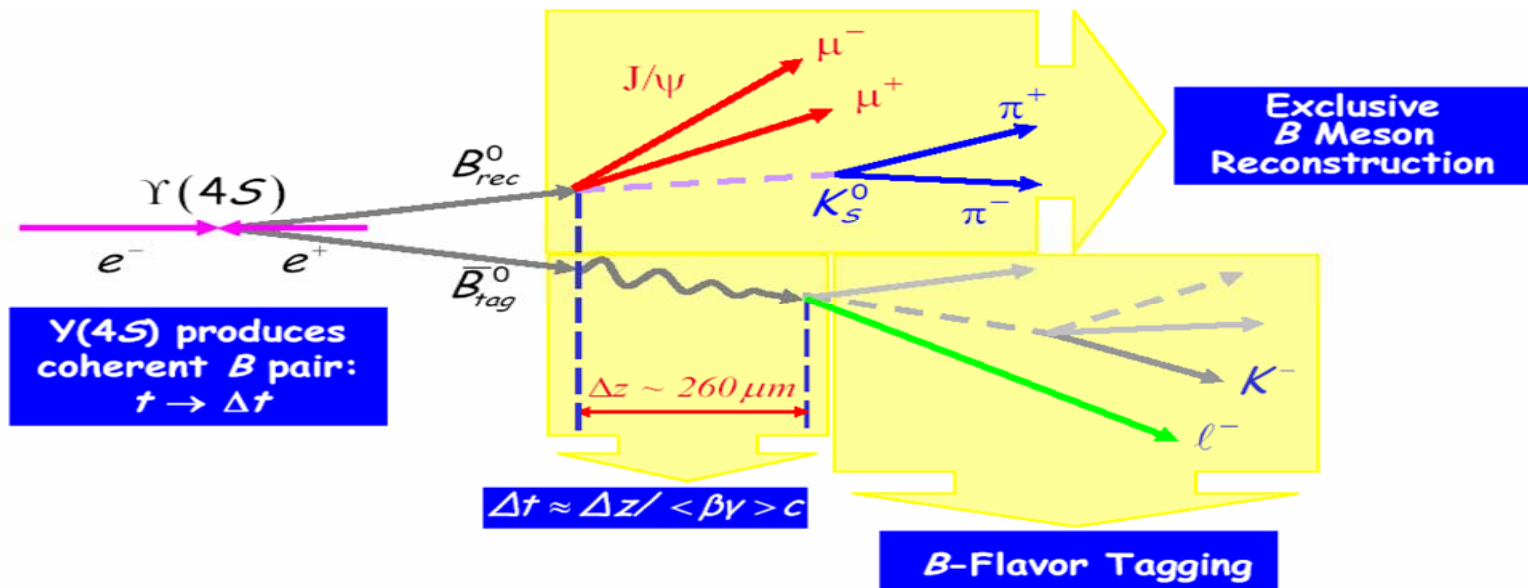
CKM Parameters at BaBar

$$\begin{bmatrix} d' \\ s' \\ b' \end{bmatrix}_{weak} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix}_{CKM} \times \begin{bmatrix} d \\ s \\ b \end{bmatrix}_{mass}$$



+ τ , charm, $\gamma\gamma$, ISR, inclusive spectra,...

The Asymmetric B Factory (PEP II)



Pier Oddone won the 2005 Panofsky Prize

“For his insightful proposal to use an asymmetric B-Factory to carry out precision measurements of CP violation in B-meson decays, and for his energetic leadership of the first conceptual design studies that demonstrated the feasibility of this approach.”

The LBNL BaBar Group



- **Faculty:** M. Battaglia, R. Jacobsen, Y. Kolomensky
- **Senior Staff:** D. Brown, R. Cahn
- **Active Retirees:** G. Abrams, J. Kadyk, L. Kerth, G. Lynch, W. Wenzel
- **Post-docs:** A. Gritsan, D. Lopes Pegna, L. Mir
- **Graduate Students:** Y. Groyzman, G. Kukartsev, T. Orimoto,
K. Tackmann, Tomohiko Tanabe
- **NERSC:** I. Gaponenko
- **Visitors:** J.Button-Shafer, C. Anders, E. Prencipe

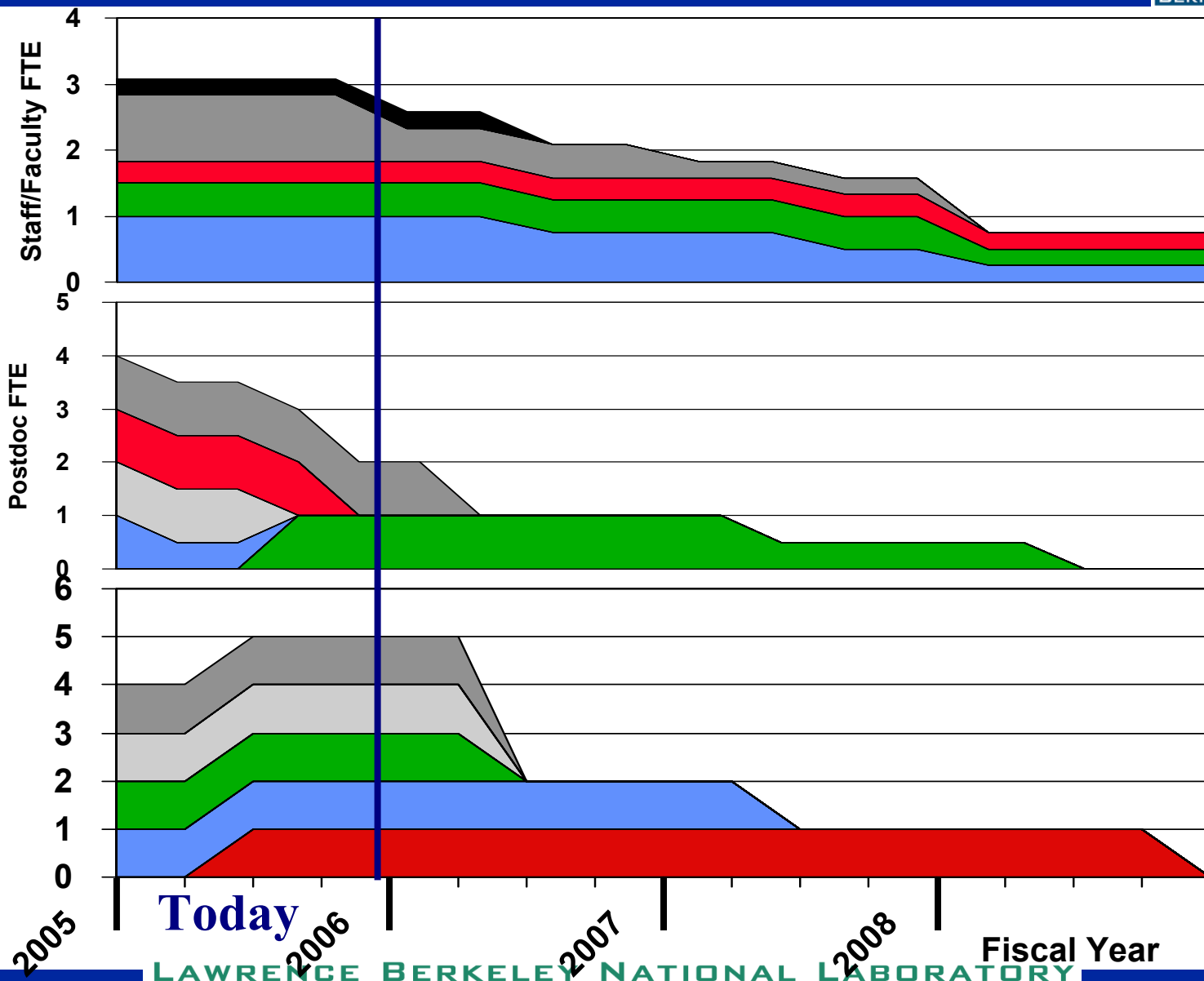
Recently Joined	Leaving Soon
------------------------	---------------------

BaBar Group Evolution



- **Historical**
 - Faculty/Staff \Rightarrow Astro(3), Neutrinos(1), FNAL Director(1)
 - Postdocs \Rightarrow Staff/Faculty(4), Private Industry(2)
 - Grad Students \Rightarrow Postdoc(1), Private Industry(2), Other(1)
- **Current**
 - 3 Grad Students leaving this coming summer
 - 2 Postdocs will leave by/before summer

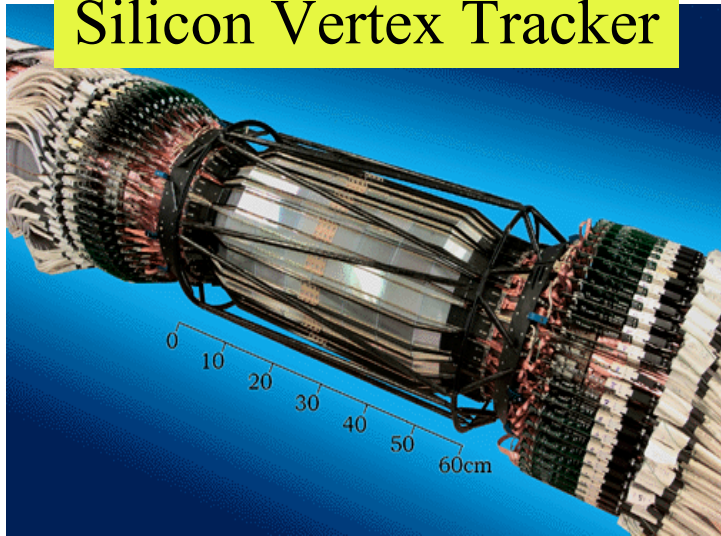
LBNL BaBar Personnel Evolution (projection)



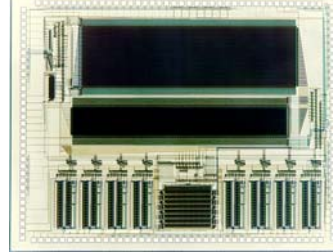
LBNL's Contributions to BaBar Hardware



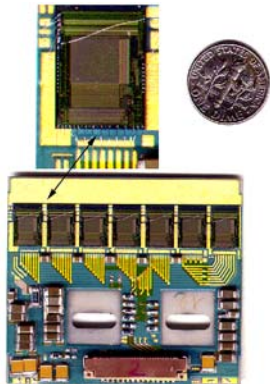
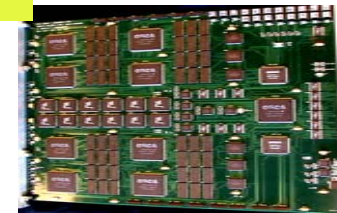
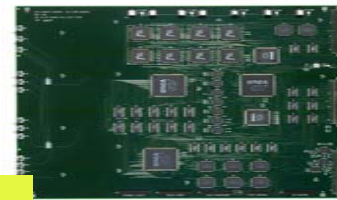
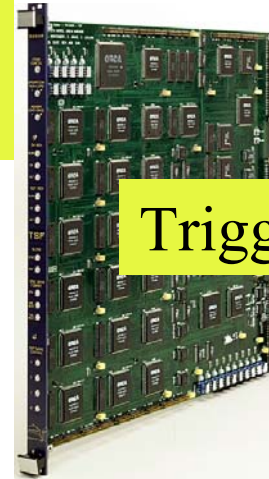
Silicon Vertex Tracker



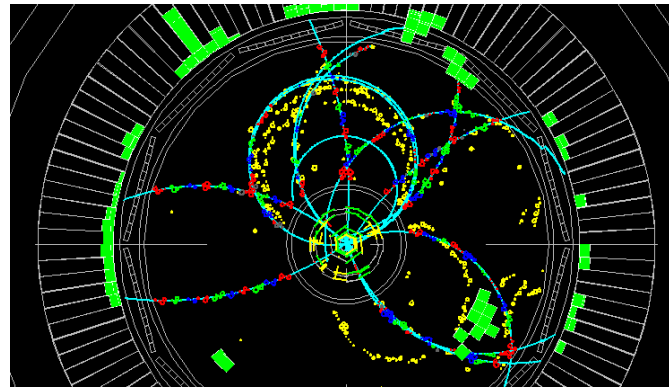
Drift Chamber
Readout IC



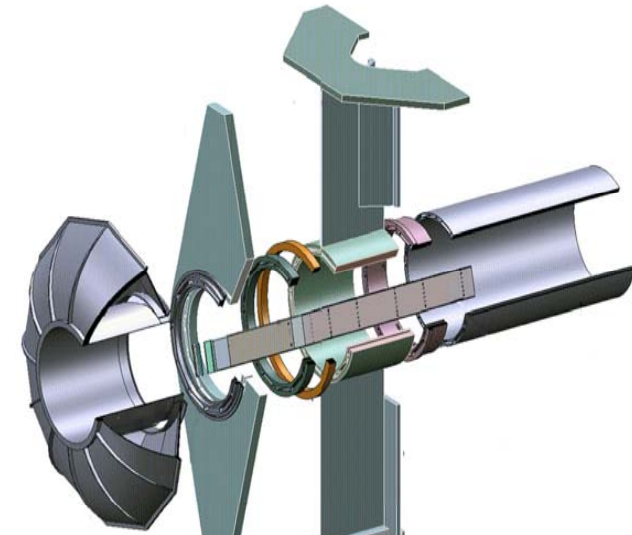
Trigger



SVT
Readout IC



Computing and
Software



DIRC

LBNL's Contributions to BaBar Computing

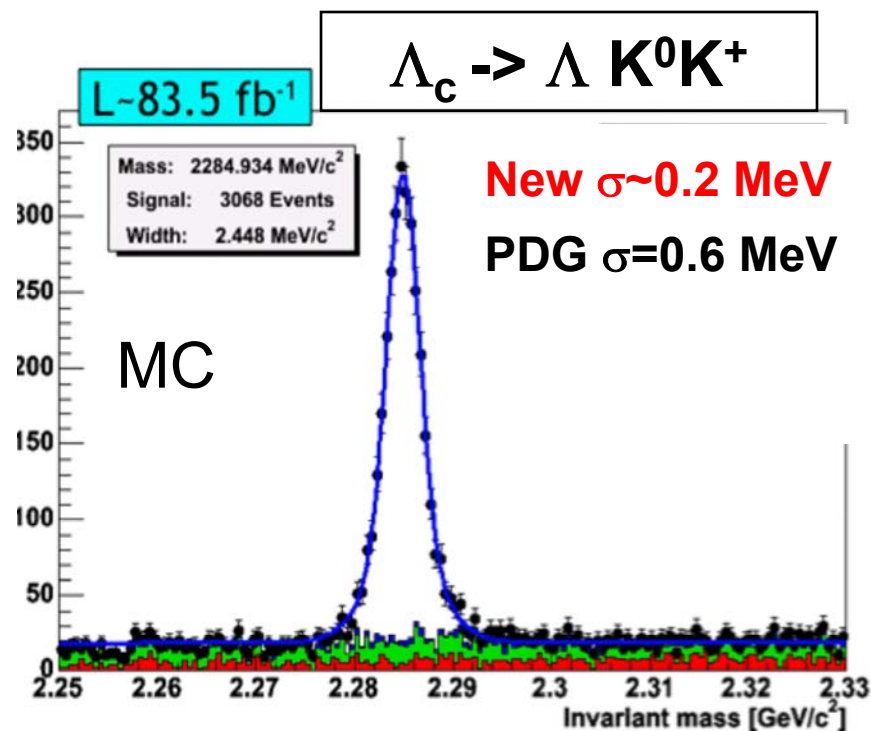
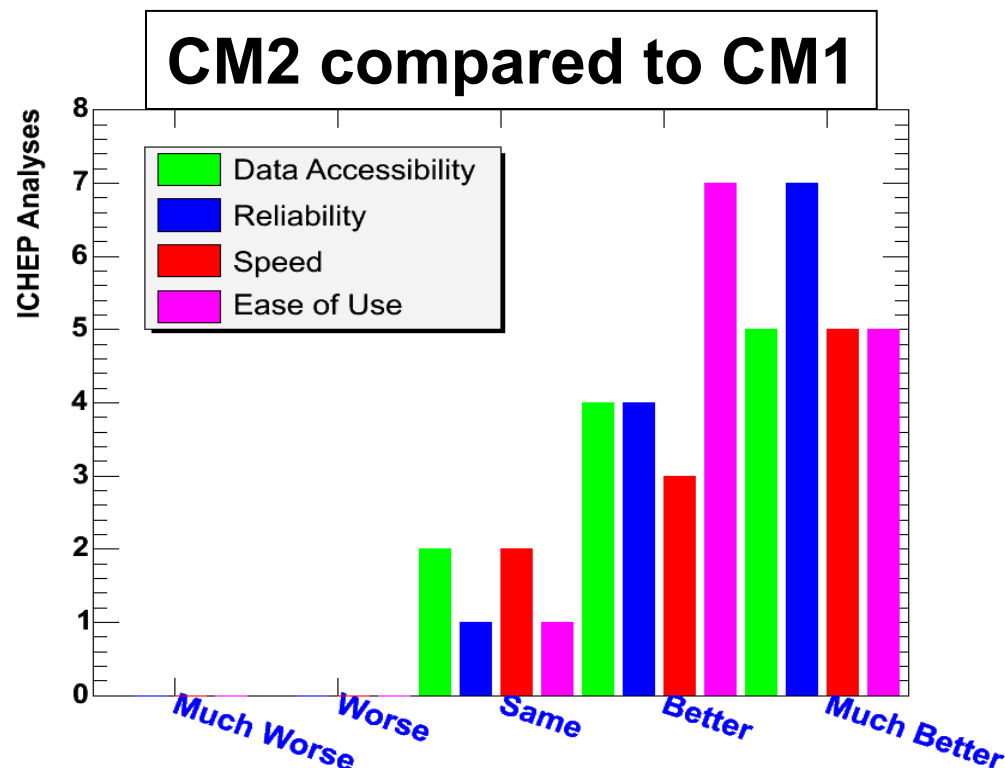


- First C++ HEP reconstruction, analysis framework
- Track reconstruction
- SVT alignment
- DIRC reconstruction
- First fully C++ online DAQ
- Online controls
- **Computing Model 2**
 - New data storage format
 - New analysis model

The Success of Computing Model 2



- Replaced Objectivity with Root-based event store
- Introduced a new data format which ...
 - Provides access to detailed detector information
 - Allows users to customize event data for their analysis
- **LBNL provided concepts, design, implementation, and leadership**



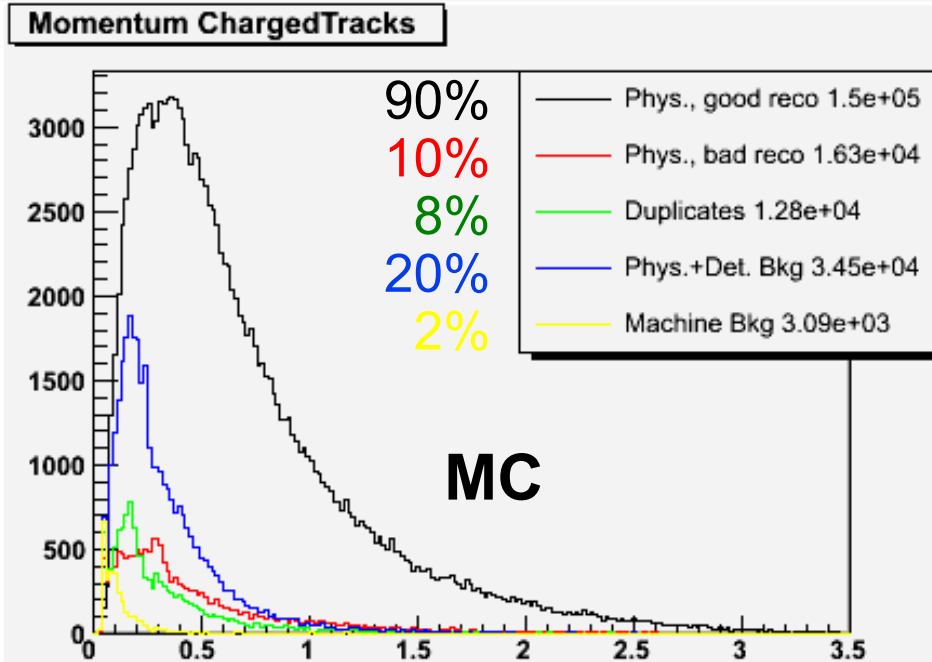
Improving BaBar Tracking



- Tracks are the core of BaBar analysis
 - Precisely reconstruct P, trajectory of charged particles
 - Track efficiency is combinatoric in most analyses
 - Improved tracking efficiency = ‘free luminosity’
- CM2 provides detailed detector-level information
- LBNL has initiated an effort to improve tracks **in analysis**

MC tracking study

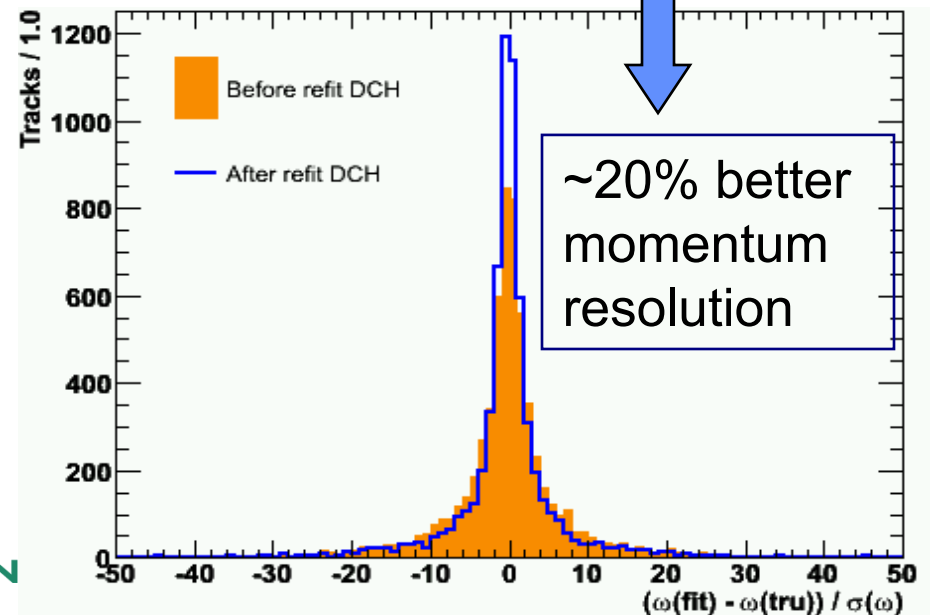
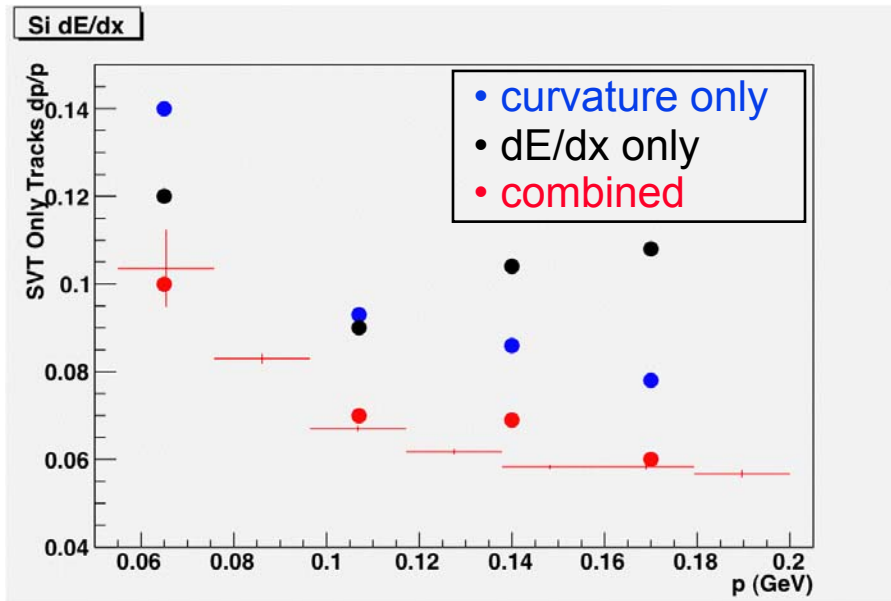
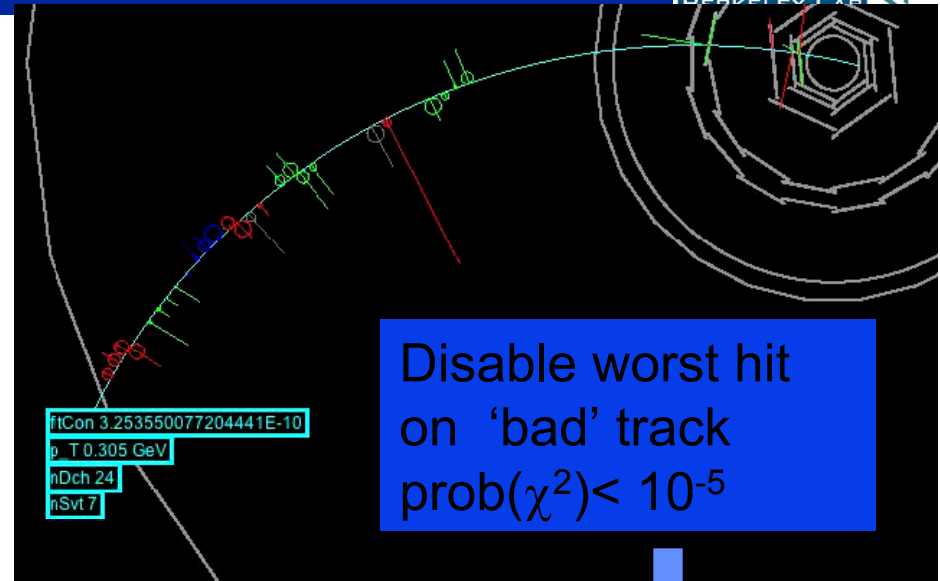
86% single-track efficiency
11% angular acceptance
3% Pat. Rec. failure
10% bad reconstruction
Parameter ‘pull’ $> 10\sigma$
30% fake tracks
Loopers, decays, ...



'Fixing' Tracks



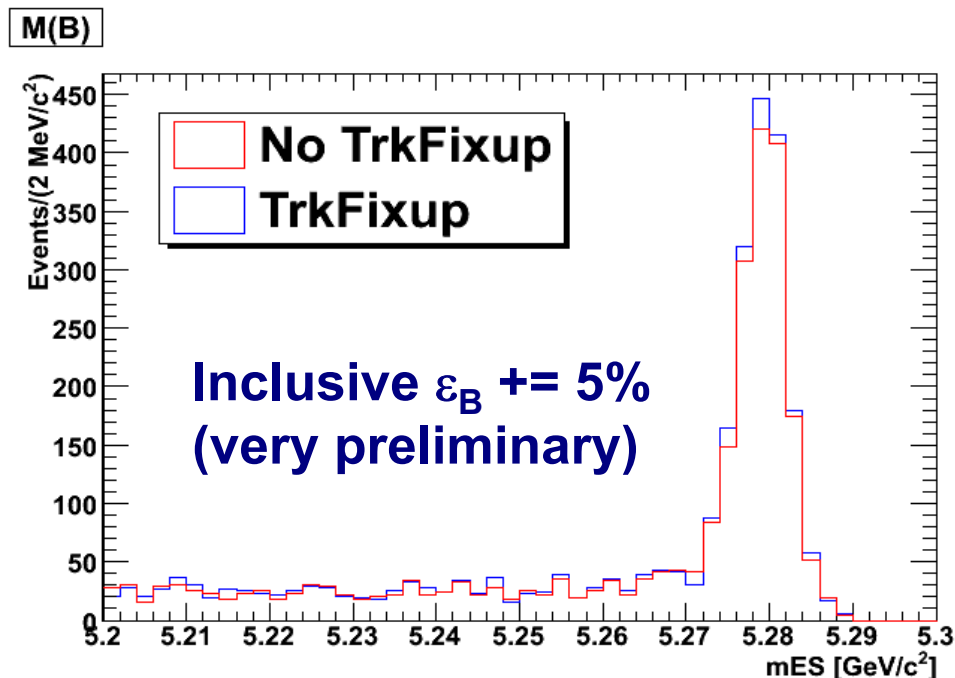
- Improve resolution
 - Hit Filtering
 - dE/dx constraint
 - Adding 'lost' Svt hits
- Filter fakes
 - loopers, decays, 'ghosts'



Track Fixup Project

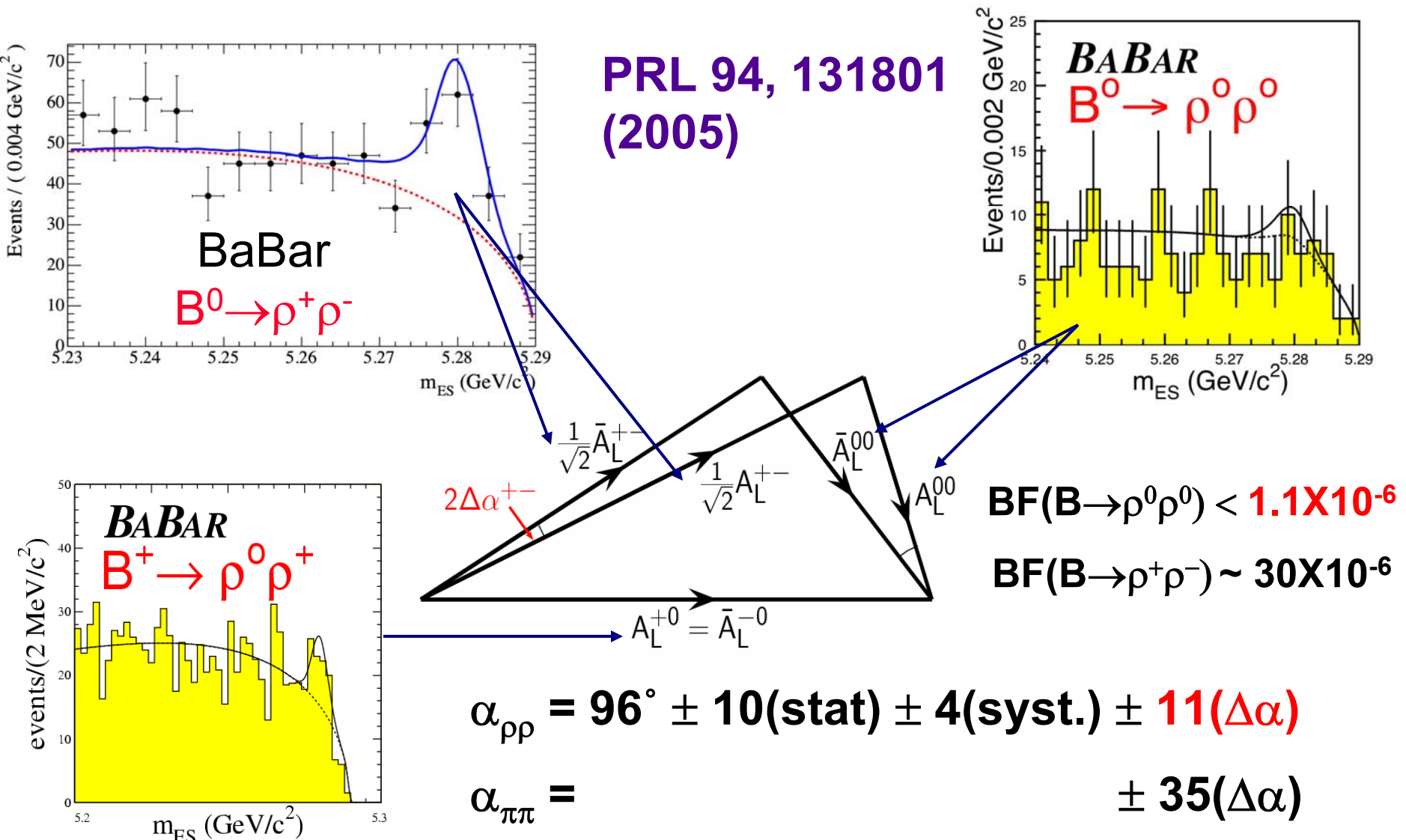


- LBNL providing leadership and (most) manpower
- Physics analysis getting involved
 - AWG representatives will validate impact on example analyses
 - LBNL will coordinate physics validation efforts
- Tentatively scheduled for deployment in summer 2006
 - After summer conference results are produced
 - Deployed unobtrusively during 'skim' production

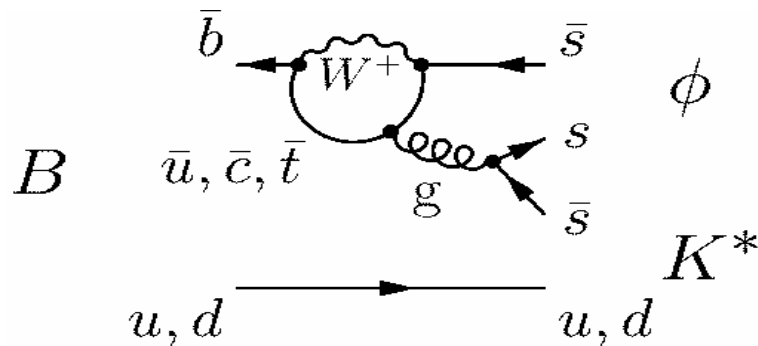




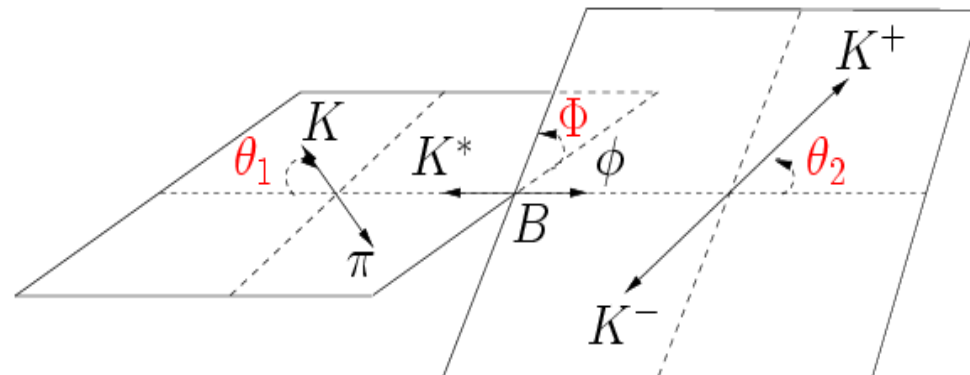
VV pioneers: extracting $\Delta\alpha$ from $B \rightarrow \rho \rho$ (Gritsan, Groyzman, Mir)



B \rightarrow ϕ K^* Polarization Puzzle (Gritsan)



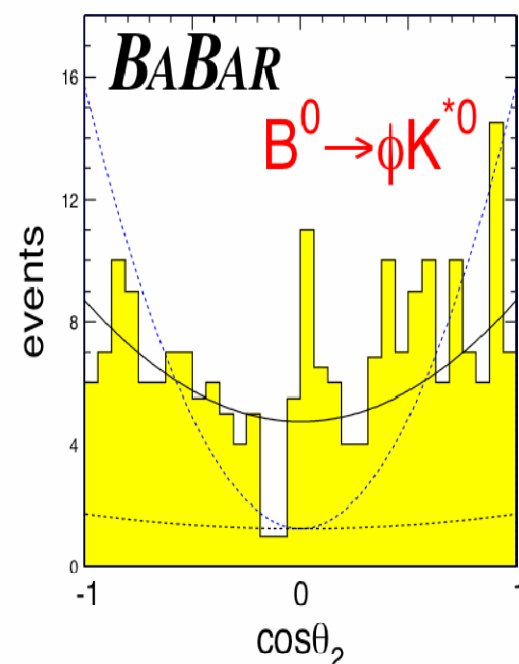
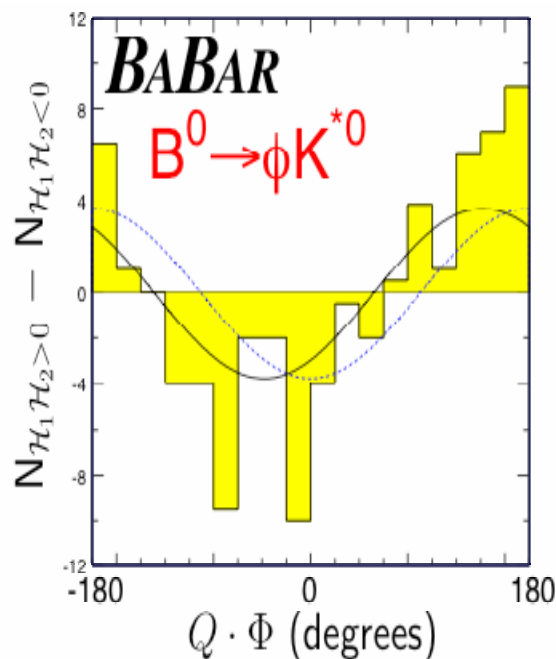
BF $\sim 10^{-5}$



Extracts from full CP analysis

PRL 93, 231804 (Dec. 2004)

- Mixed polarization
 - Additional SM process?
 - New Physics?
- Non-zero (strong) phase
 - Contrary to factorization

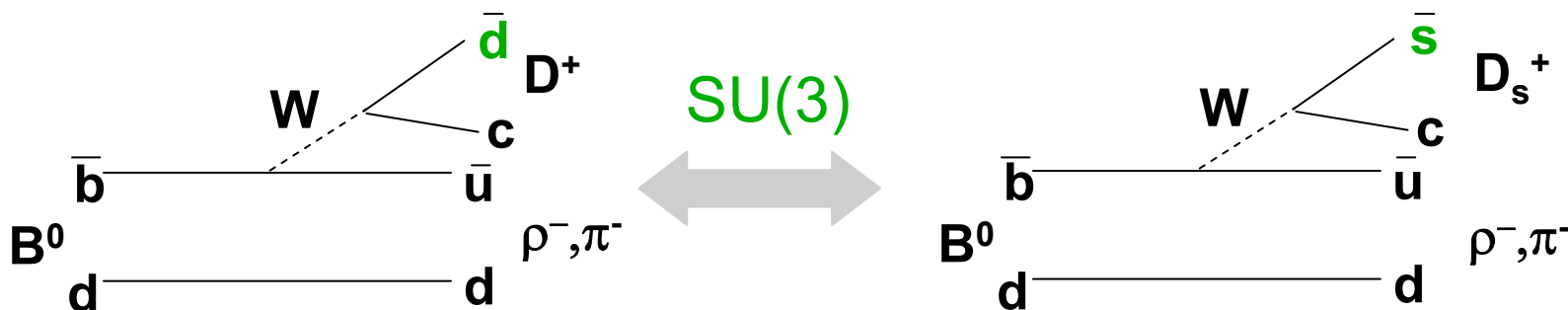


Helping constrain γ : $B^0 \rightarrow D_s^{(*)+} \rho^-, \pi^-$ (Orimoto, Kolomensky)



- $B^0 \rightarrow D \rho, \pi$ sensitive to $\sin(2\beta + \gamma)$
 - λ_c^2 suppressed amplitude interference!
- Rates from SU(3) related D_s modes
 - ~20% error from SU(3) breaking

Mode	Measured BF
$B^0 \rightarrow D_s^+ \rho^-$	$< 1.9 \times 10^{-5}$ (90% C.L.)
$B^0 \rightarrow D_s^{*+} \rho^-$	$< 5.3 \times 10^{-5}$ (90% C.L.)
$B^0 \rightarrow D_s^+ \pi^-$	$3.2 \pm 0.9 \pm 1.0 \times 10^{-5}$
$B^0 \rightarrow D_s^{*+} \pi^-$	$< 4.1 \times 10^{-5}$ (90% C.L.)
$B^0 \rightarrow D_s^- K^+$	$3.2 \pm 1.0 \pm 1.0 \times 10^{-5}$
$B^0 \rightarrow D_s^{*-} K^+$	$< 2.5 \times 10^{-5}$ (90% C.L.)

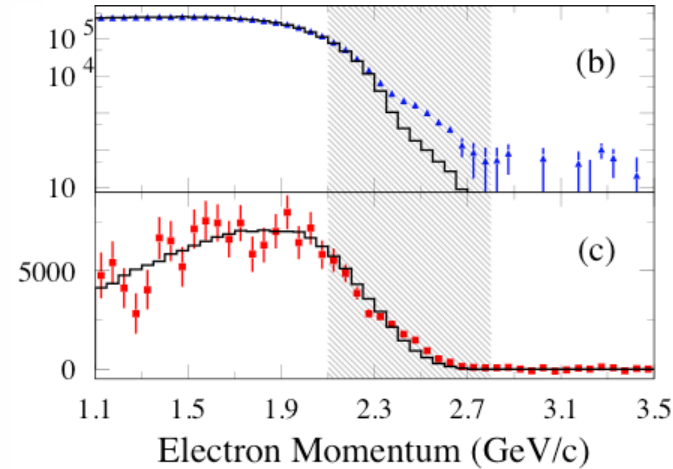
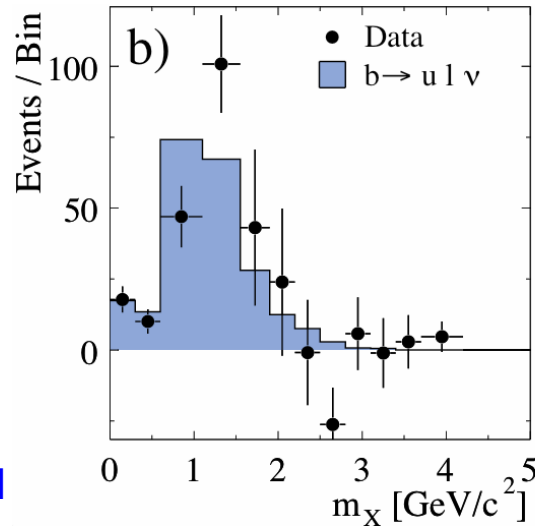
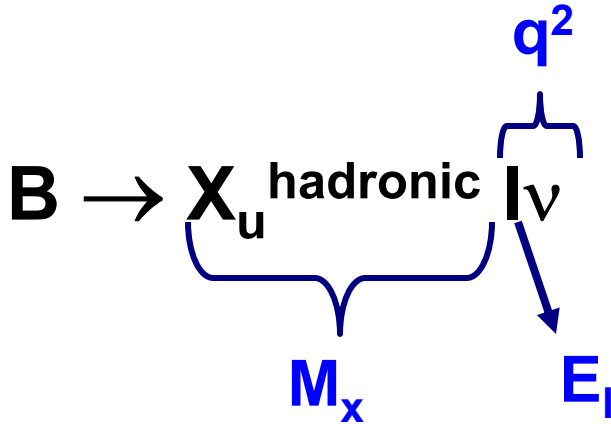


Semi-leptonic B decays



- **Sensitive to V_{ub} and V_{cb}**
 - **Fundamental CKM parameters**
 - **V_{ub}/V_{cb} vs β allows a stringent SM consistency test**
- **Can be used to determine m_b**
 - **Fundamental Standard Model parameter**
 - **$\Gamma_{\text{weak}} \propto m_b^5$, so important for rate estimates**
 - **<1% precision needed for ILC Higgs tests**
- **LBNL group has been strongly involved in the past**
 - **C. LeClerc thesis ($B \rightarrow D^* l \nu$ lifetime, mixing)**
 - **M. Gill thesis ($B \rightarrow D^* l \nu$ Form Factors, publication in review)**

V_{ub} from inclusive semi-leptonic decays (Battaglia, Tackmann)



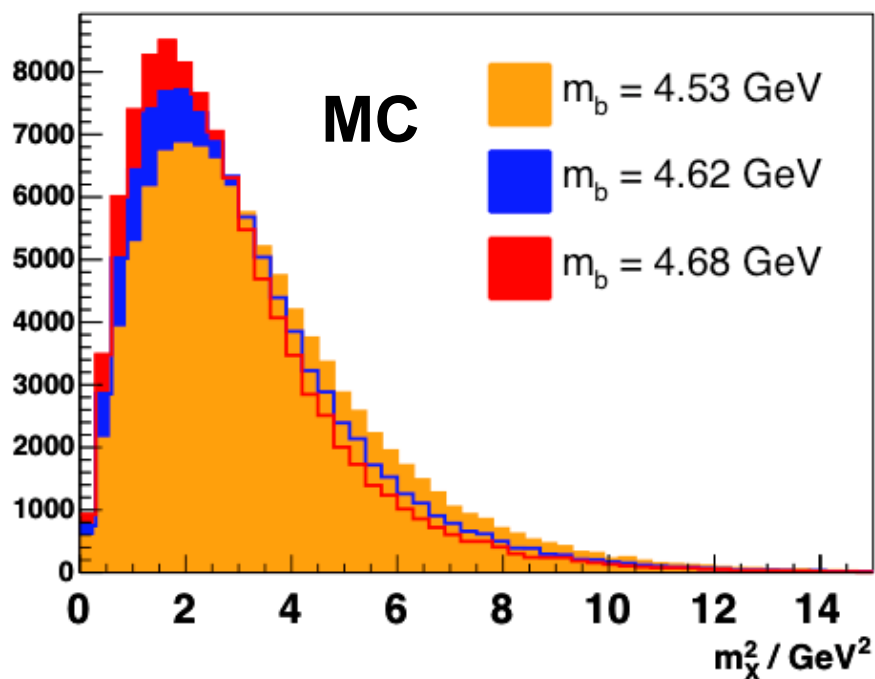
LBL involvement

Variable	V_{ub} ($\times 10^{-3}$)	Exp. Error	HQE param error (m_b, \dots)	Other theory error
M_x	4.77	± 0.4	$+0.68-0.43$	± 0.13
$M_x - q^2$	4.92	± 0.53	± 0.46	—
$q^2 - E_l$	3.95	± 0.27	$+0.58-0.42$	± 0.25
E_l	4.44	± 0.25	$+0.42-0.38$	± 0.22

Constraining m_b with M_x moments (Battaglia, Tackmann)

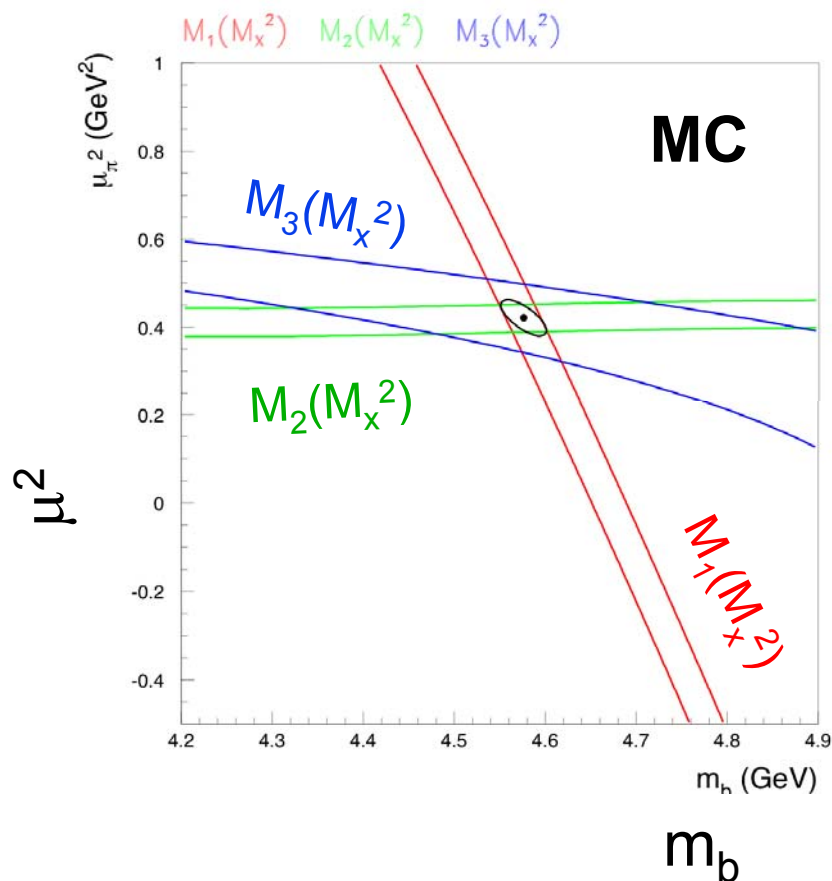


X_u Mass²



m_b also constrained in
 $B \rightarrow s\gamma, \dots$

$b \rightarrow u$ moments 10X
more sensitive to
 m_b than $b \rightarrow c$



$B \rightarrow X_c l \nu$ (Battaglia, Lopes-Pegna)

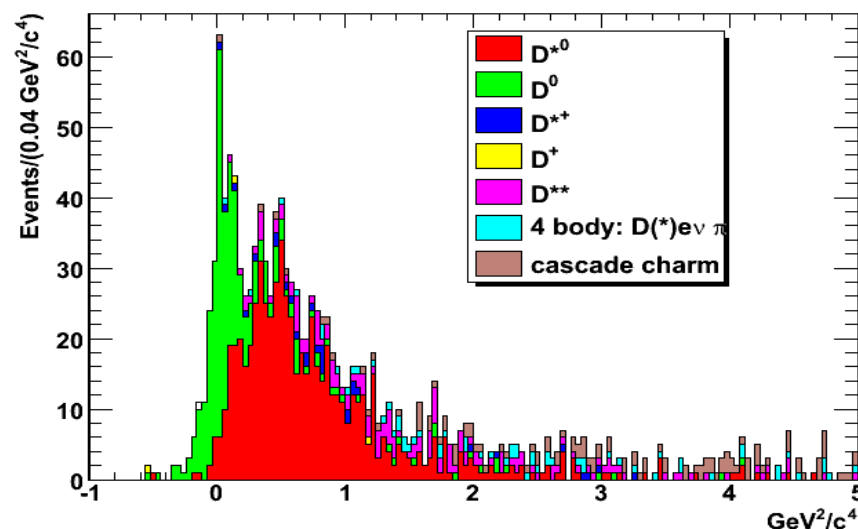


PDG 2004

Decay Mode	Branching Fraction
$B^0 \rightarrow l^+ \nu_l + \text{anything}$	$10.5 \pm 0.8 \%$
$B^0 \rightarrow D^*(2010) - l^+ \nu_l$	$5.44 \pm 0.23 \%$
$B^0 \rightarrow D^- l^+ \nu_l$	$2.14 \pm 0.20 \%$
$B^0 \rightarrow D^{*-} l^+ \nu_l$??
$B^0 \rightarrow D^{*-} n \pi l^+ \nu_l$??

- 30% of $B \rightarrow X_c l \nu$ BR unknown or has large uncertainties
 - Affects V_{cb} , V_{ub} measurements through crossfeed + background
- D^{**} poorly understood
 - Broad + narrow resonances
 - Non-resonant contributions
- New technique using hadronic B reconstruction
 - 5X better m_{ν}^2 resolution
 - Preliminary result spring 2006

MissNu2

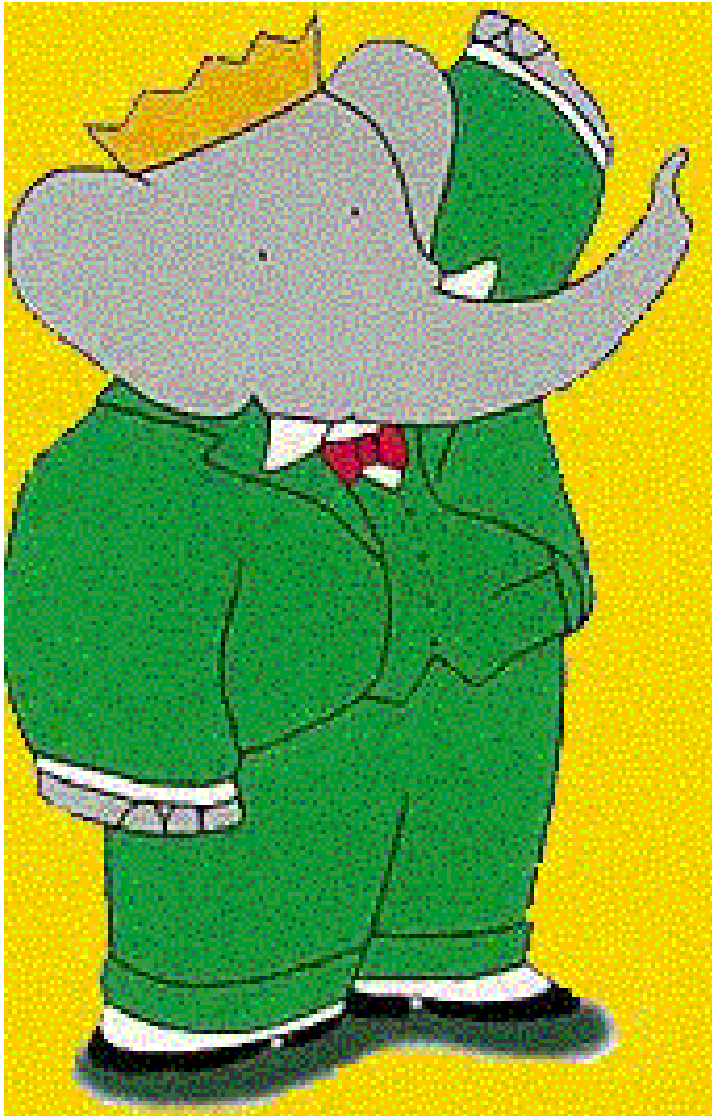


Other LBNL BaBar Analysis Contributions



- $B^+ \rightarrow \rho^0 K^{*+}$ and $B \rightarrow f^0 K^{*+}$ (L. Mir)
 - Final results by summer 2006
- $B^+ \rightarrow \eta' K^+$ search (G. Kukartzev, A. Gritsan)
 - Possible gluonium enhancement
- $B \rightarrow \Lambda_c X l \nu$ Branching Ratio
 - Preliminary results by summer 2006
- Publications board chair (R. Cahn)
- Physics reach studies (A. Gritsan, L. Mir)
 - Future of $\rho\rho$, angle α measurements
 - Future of Vector-Vector studies and $\sin 2\beta$ from penguins

FY2006 DOE Budget



- “In order to fully exploit the unique opportunity to expand our understanding of the asymmetry of matter and antimatter in the universe, a high priority is given to the operations, upgrades and infrastructure for the B-factory at SLAC.”
- “... B-factory operations are terminated by **FY 2008** at the latest.”

(Staffin/DOE)

P5 Review of BaBar

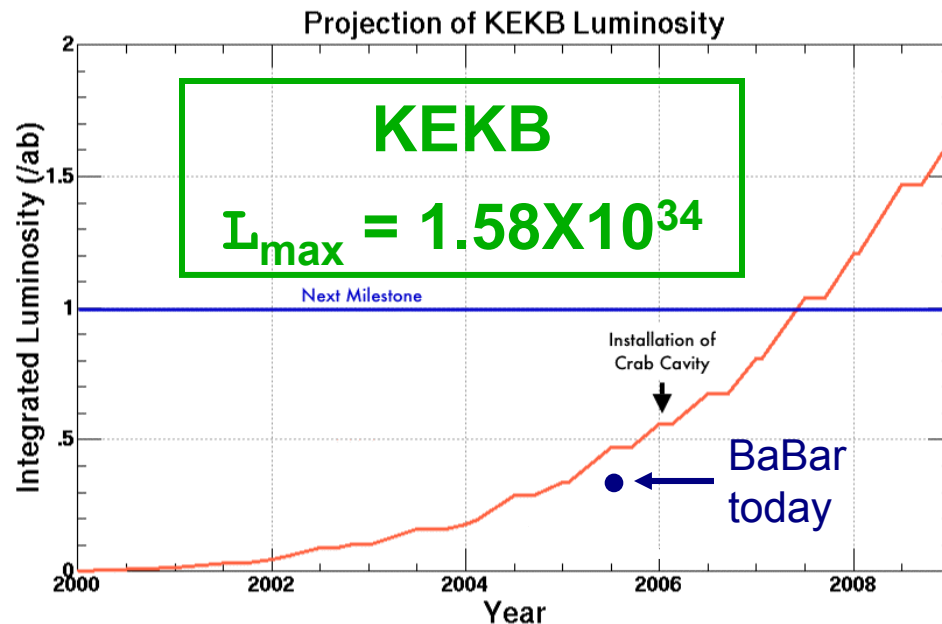
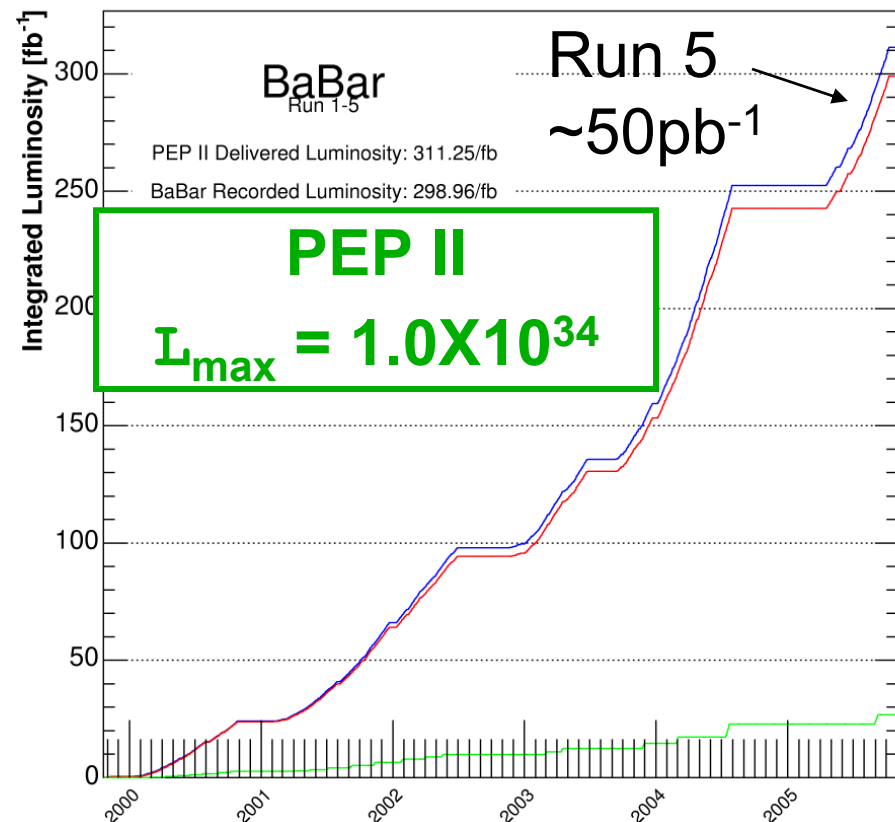


- DOE/NSF HEPAP review of BaBar October 2005
- Charge from DOE: **“What factors might lead to stopping B-factory operations one year, or two years earlier than planned”**
- Strong presentations from BaBar and others
 - B-physics is still interesting
 - Our results will not be erased by LHC or ILC
 - BaBar is still active and competitive
 - 2 B-factories are still complementary
- Report due end November

Competing with Belle



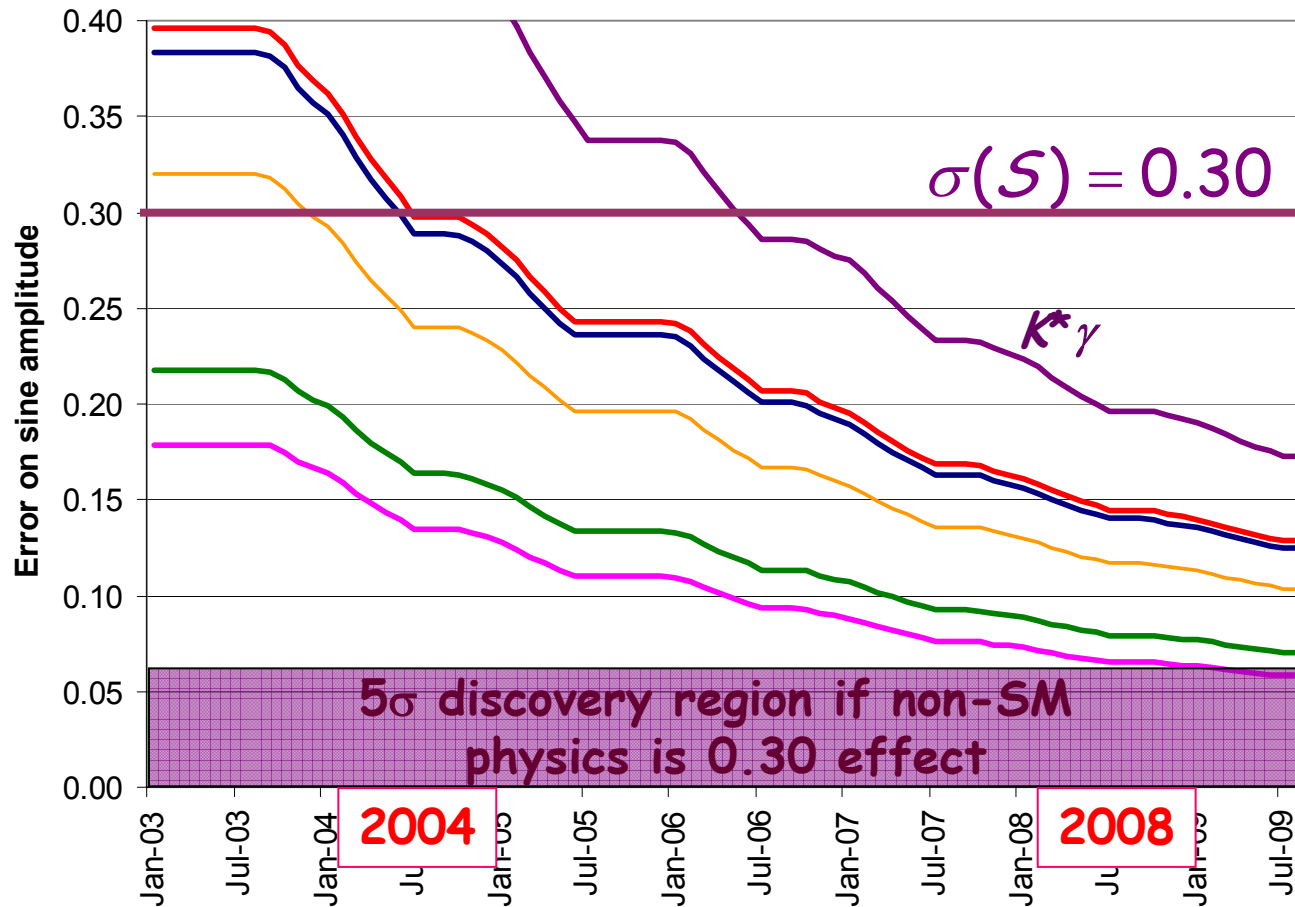
11/04/2005 04:16



S	Belle				BABAR				Errors/Luminosity			
	S	stat err	lumi	Untag sample	S	stat err	lumi	Untag sample	Belle	BABAR		
Mode	S	stat err	lumi	Untag sample	S	stat err	lumi	Untag sample	st*sqrt(L)	st*sqrt(L)	Perf Ratio	Lumi Ratio
phiK0	0.060	0.330	253	175	0.500	0.250	205	212	5.249	3.579	1.466	2.150
etapK0	0.650	0.180	253	512	0.270	0.140	205	819	2.863	2.004	1.428	2.040
KKK0	0.490	0.180	253	399	0.550	0.170	205	452	2.863	2.434	1.176	1.384
f0K0	-0.470	0.410	253	102	0.950	0.320	192	152	6.521	4.434	1.471	2.163
pi0K0	0.300	0.590	253	173	0.350	0.300	205	300	9.385	4.295	2.185	4.773
ccbarK0	0.728	0.056	140	5417	0.722	0.040	205	10320	0.663	0.573	1.157	1.339
pipi	-1.000	0.210	140	373	-0.300	0.170	205	467	2.485	2.434	1.021	1.042
rhopi S	-0.280	0.230	140	483	-0.100	0.140	192	1184	2.721	1.940	1.403	1.968
rhopi A+-	-0.020	0.160	140	483	-0.210	0.110	192	1184	1.893	1.524	1.242	1.543
rhopi A-+	-0.530	0.290	140	483	-0.470	0.140	192	1184	3.431	1.940	1.769	3.129
Averages											1.432	2.153

BaBar physics sensitivity/L ~40% above Belle

Snapshot I: Summer 2008 (D. MacFarlane)



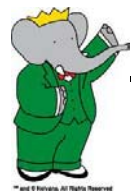
Luminosity expectations

2004=240 fb⁻¹
2008=1.0 ab⁻¹

$f_0 K_S$
 $K_S \pi^0$
 ϕK_S
 $\eta' K_S$
 $K K_S$

Projections are statistical errors only;
but systematic errors at few percent level

Golden modes
reach 5
sigma level



LBL's Future in BaBar



- LBNL will participate in BaBar through FY08
 - Analysis
 - Detector support
 - SVT refurbishment probably **NOT** required
 - Software support
 - Tracking improvements
- The BaBar dataset will remain useful after 2008
 - Final publications will be years after last event
 - Maintain an active *Electrons* physics program while waiting for ILC decisions
 - Students and postdocs can analyze real data while performing detector R+D

Conclusions



- LBNL has made huge contributions to the current success of the BaBar program
- BaBar is not yet finished!
 - Only **~25%** of the total events have been seen
 - We are still improving how we use our data
 - We are still discovering new physics results
- LBNL will continue to participate in BaBar
 - Support the competition with Belle
 - Fully exploit the BaBar data
 - Facilitate the passage to HEPs future
- **Key concern:** can we keep the group strong enough to be effective up to and through 2008?